

Radar Investigations of Earth-Approaching Asteroids

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Much useful information about physical and dynamical properties can be obtained from radar observations of near-Earth asteroids (NEAs) that come within reach of the Arecibo and Goldstone telescopes. Resolution of echoes in time delay and Doppler frequency can be used to synthesize images that can reveal target shapes and surface features at sub-100-m scales. If the rotational phase coverage is adequate and non-equatorial aspects are sampled, then the images can, in principle, be inverted to generate a model of the asteroid's 3-D shape. Such an inversion might incorporate parameters for spin vector components and for the delay-Doppler trajectory of the asteroid's center of mass.

In 1989, a sequence of radar images of 4179 Castalia (1989 PB), with delay resolution equal to 2 microseconds (300 m), showed it to consist of two kilometer-sized lobes in contact. In late 1992, observations of 4179 Toutatis yielded daily images placing hundreds to thousands of pixels on the asteroid, with delay resolution as fine as 0.125 microseconds (19 m) and fractional astrometric precision as fine as 2×10^{-9} . Toutatis has an unusual spin state and consists of two irregular, heavily cratered components in contact. Echoes from several other NEAs show evidence for shape bifurcation, so "contact binary" configurations may not be uncommon in the population.

Opportunities for radar investigation of NEAs will expand significantly upon completion of upgrades in the Arecibo and Goldstone instruments. Arecibo alone should be able to produce thousand-pixel images of several NEAs each year. A dedicated optical search program (e.g., the proposed Spaceguard Survey) could discover some 100,000 NEAs, most of which would traverse the Arecibo/Goldstone radar windows at least once every few decades.